Submission 18

Comparison of Transport-Based and Natural River Recovery Options

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The two major questions are: 1) can Snake River spring/summer chinook salmon be recovered with continued smolt collection and transportation?; and 2) how much restoration of the natural migration corridor would be needed to recover Snake River spring/summer chinook?

The prospective modeling in the Weight of Evidence (WOE) Report gives insight into what assumptions one has to believe to answer the above questions. For instance, for options A1/A2 to effectively recover Snake River spring/summer chinook, one must believe the points highlighted below.

Transportation Based Recovery Options (Options A1/A2)

Section 4.3 uncertainties in hypotheses in the WOE Report about the natural river option (which historically sustained healthy populations of spring/summer chinook under similar configurations) need to be balanced with uncertainties about technologically based options such as A1 (which have not worked historically). Section 4.3 emphasizes uncertainty in the case of A3, although PATH appears to have adopted quite optimistic hypotheses about A1/A2.

The historical performance of Snake River stocks under A1 (and recent operation) has been poor, even with transportation. There is no historical element to Options A1 or A2 that gives us confidence that Snake River stocks can be recovered with these options. Further, there are no examples from other river systems that indicate smolts can be successfully mass-transported around several large hydroelectric dams as in options A1/A2 (Mundy et al. 1994).

Numerous biological mechanisms have been identified that may explain delayed mortality of smolts that migrate through the hydropower system and of smolts subjected to collection and transportation around the dams (see Preliminary Decision Analysis, Section A.3.3.1). These include: altered saltwater entry timing which is poorly synchronized with physiological state of smolts; stress from crowding and injury during bypass, collection, holding in raceways, and transportation; increased vulnerability to disease outbreak due to crowding and stress; and increased vulnerability to other stressors in the environment or to predation as a result of passage-related stress.

In addition, the current configuration and operation of the hydrosystem, which is similar to A1 and A2, presents the Snake River salmon populations with ongoing evolutionary challenge. Each year a large segment of the outmigration is transported. Prior to collection for transportation for all fish, and through the entire hydrosystem for those not transported, fish have three ways to pass each dam encountered. They will be either spilled over the dam, bypassed around the turbines, or pass through the turbines. Whether a smolt is transported or not, and the routes of passage at a particular dam, are determined by changes in management strategies and interaction of natural conditions with these changing strategies, and other chance elements.

Each generation, in fact each year, the probability of passing the hydrosystem through each of the myriad unique pathways changes, sometimes drastically, from the previous year and generation. In the juvenile migration gauntlet, the Snake River populations face the equivalent of a rapidly fluctuating environment; and under A1 and A2, the fluctuations persist into the indefinite future.
The parents' experience passing the hydrosystem may have no relation to the hydrosystem experience of their progeny. Opportunities for natural selection for useful characters during this period are either eliminated altogether, or worse, are replaced by artificial selection pressures. Some of the artificial challenges such as dam passage may favor fish that behave in a certain way, while other hazards of the hydrosystem favor the opposite behavior. For example, fish that tend to be found at optimal depth for bypass or spill at dams may exhibit behavior that leaves them at sub-optimal depths for predator avoidance, for surviving crowded raceways, high temperatures,
etc. However, in a system with four less dams, the fish would experience a more predictable environment for juvenile and adult migration conditions.

Outcomes of transportation-based recovery options (A1/A2) are substantially less robust to different hypotheses than are outcomes of the natural river drawdown option (A3) in the weight of evidence (WOE) report. Unweighted results for A2 for the different jeopardy standards differ substantially between passage/transport models. The fraction of model runs that met the three jeopardy standards for CRiSP/T4 were 0.61 (24-year survival), 1.0 (100-year survival) and 0.73 (48-yr recovery). The fractions for FLUSH/T1 were much lower: 0.10 (24-year survival), 0.37 (100-year survival) and 0.12 (48-yr recovery).

It is also noteworthy that option A2 (maximum transportation) does not substantially outperform A1 (status quo transportation) for either CRiSP/T4 or FLUSH/T1. That is, there appears to be little room for improvement over current operations with a future transportation-based recovery option. This is not surprising, given that most Snake River spring/summer chinook smolts have been collected and transported most years since 1977.

In the WOE report, population performance for the transportation-based options (A1 and A2) exceeded by that of option A3 for only 2% of the models runs (Table 3-1). Most (88%) of these exceptions were for the short-term (24-year) survival standard, with many more of the exceptions represented by CRiSP/T4 hypotheses (83%) than by FLUSH/T1 hypotheses (5%). It is also important to note that none of the 960 model runs resulted in performance of options A1/A2 exceeding option A3 performance by greater than 0.05 probability.

The sensitivity analyses in Tables 3-3 to 3-5 indicate that 75% of the 106 CRiSP runs where A1/A2 > A3 were using the TURB1 or TURB5 assumptions, where CRiSP incorrectly implemented D's specific to TURB4 assumptions (see D analysis comments in Appendix 22). Second, 72% of the 106 runs used FGE 1 (the more optimistic FGE assumption), which confers the greatest transport benefit. Third, 97% of the 106 runs used a combination of TJUVb and EJUV1 (the long transition period and the lower juvenile survival rate at equilibrium, the pessimistic assumptions about drawdown). Third, 70% of the 106 runs used PRER2 (the long delay period before dam breaching). This result is predictable given the 24 year survival standard and should be discounted given this is a policy decision.

Comparison of empirical stock performance with the A1 prospective results suggests that PATH has selected more optimistic hypotheses for the incremental hydrosystem improvements already in place (e.g., Fig. 3-9; Fig. 4-4 and accompanying text). Williams et al. (1998) also commented (7/27/98) that projected escapements for A1 over-estimated actual recent escapements by 52% for FLUSH/TURB5 and 85% for CRiSP/TURB4 (both assumed FGE2/PREM1). NMFS' conclusion was "…spawning abundances projected by both aggregate hypotheses appear to be unreasonably optimistic [for option A1], or both of them are excluding some source of mortality that has been operating in recent years." There is considerable evidence that A1 and A2 assumptions are overly optimistic while A3 assumptions are overly pessimistic, which we discuss below. We address the alternative hypotheses about non-hydropower sources of mortality elsewhere in our comments.

Because assumptions about transportation effectiveness have a huge influence on model outcomes, the data and assumptions in the transportation studies should be kept in mind when interpreting model results. A primary data limitation is that the controls were not fully representative of in-river migrants (see Marmorek and Peters 1998, Appendix A, p. 76-79). In an independent peer review of transportation research, Mundy et al. (1994) considered the “control” group to be another treatment group that is used for comparative purposes. Various assumptions and adjustments need to be made to control group survival estimates to mimic survival of true in-river migrants, which carry into the estimates of T/C and D.

Stock performance has been poor since mass transportation began in the mid-1970s. Recent estimated SARs for aggregate wild Snake River spring/summer chinook have ranged from 0.2% to 1% (Appendix submission 10), substantially less than projected prospectively for option A1 (1.5% to 4.2%; Fig. B.5-2 in Marmorek and Peters 1998). In addition, recent SARs of transported wild smolts have been much lower than the 2% to 6% range defined in Toole et al. (1996) and have shown no indication of an increasing trend (Fig. A3.3.1-1 in Marmorek and Peters 1998). Not only have SARs remained extremely low, there is no indication that the gap has narrowed between performance of Snake River stocks and downriver stocks, as might be expected if transportation and hydrosystem improvements were merely masked by generally poor ocean conditions for all stocks. In the 1996 Retrospective Analysis, Deriso et al. (1996) estimated the differential instantaneous mortality rate (mu) between Snake River and downriver populations. Estimates of mu do not indicate a decrease in mortality over time (Fig. 5-1 in Deriso et al. 1996).

In previous and current PATH analyses, less optimistic assumptions about transport effectiveness have had better fits to stock performance data (spawner-recruit and SAR). In Deriso et al. (1996), an assumption of high, constant post-release survival of transported fish (CRiSP/T2) showed the poorest fit to mu, whereas less optimistic transport assumptions showed better fits. This pattern appears to have continued in the current analysis: FLUSH/TURB5 showed the best fit to both spawner-recruit data and SAR data (in the alpha model), while CRiSP/TURB4 showed the worst under the alpha model (Tables 4-2 and 4-3). Note that only the more optimistic transport model in FLUSH (TRANS1) was compared in this analysis.

Preliminary estimates of ‘D’ for fall chinook, a different race of the same species, also suggest assumptions about transport effectiveness are over-optimistic. In the fall chinook analysis, ‘D’ was estimated as free parameter in the MLE life cycle model from the stock recruitment data. For both CRiSP and FLUSH estimated ‘D’s were substantially less than one (D’s for FLUSH = 0.04 and for CriSP =0.10-0.13)(Deriso notes on fall chinook, July 20, 1998).

One important implication of dropping a less optimistic transport model (FLUSH/T2) from the decision analysis needs to be identified. The draft states that “[b]ecause A3 is favored by virtually all FLUSH runs, omitting TRANS2 will have no effect on the relative ranking of actions.” (p. 11, lines 14-15). This may be true, but dropping a less optimistic, plausible hypothesis about transportation effectiveness will have the effect of understating the risk of current management.

There are a number of other examples where PATH has adopted the more optimistic assumptions for A1/A2. These include: 1) direct barge survival rate = 0.98; 2) no increase in descaling rates in the future with extended length screens; 3) high levels of direct bypass survival (0.97 to 0.99); 4) an assumption that BiOp flows and spill targets would be met; 5) Snake River and John Day projects are operated at

Minimum Operating Pool (MOP); and 6) a spill effectiveness of 1:1 at collector projects, which likely overestimates the proportion of smolts that are available to be collected and barged under A1/A2. This latter point is especially problematic when coupled with an optimistic assumption about transport effectiveness.

In addition, PATH used two predator removal effectiveness assumptions to bracket possible future responses (0% and 25% reduction in predation mortality rates). Consumption indices and diets of northern squawfish, smallmouth bass, and walleye have changed little during the predator removal period when data were pooled within a reservoir or across large sections of the river (Peterson 1998; Submission 7). This suggests that the assumption of 25% reduction in predator removal for the current dam and reservoir configuration is overly optimistic. (See also evidence for minimal predation loss in free flowing river conditions as compared to in the altered hydrosystem below and in Appendix 19).

PIT tag data on adult return rates for wild spring/summer chinook, subjected to different passage routes at the dams, suggest that collection/bypass may not be as benign as modeled in PATH (R. Kiefer, IDFG pers. comm.; Marmorek and Peters 1998, Appendix A, p. 78). These data also indicate that wild smolts transported in 1995 and returning as adults in 1997 and 1998 did not do any better than smolts migrating in the reservoirs in 1995 which passed the dams via spillways or turbines (ibid.). The SAR point estimate of these in-river (uncollected) migrants (0.41%) was actually higher than that of transported smolts (0.37%), although the difference was not statistically significant. Based on PATH estimates of direct mortality through bypass, spill and turbine routes, these results suggest delayed mortality increases as a function of the number of times a fish is bypassed (Marmorek and Peters 1998, p. A-96). Note that recent NMFS estimates of collection/bypass survival for fall chinook (0.88) and steelhead (0.95) are also lower than values used in PATH (0.97-0.99) for spring/summer chinook (W. Muir, NMFS, pers. comm.).

The implicit assumption that descaling would not increase with extended length screens, if false, would seemingly have large implications in the current CRiSP formulation of D values under A1/A2. In this case, future CRiSP D values for A1/A2 would be lower than currently modeled, and stock performance would be poorer. There are several reasons to hypothesize that descaling might increase in the future with extended length screens, based on tests at McNary Dam [B. Heinith, Columbia River Intertribal Fish Commission, pers. comm.]

Since the BiOp was implemented in 1995, some of the targets assumed in the modeling for A1 have not been met. The Snake River and John Day projects have not operated at MOP, which results in optimistic water and fish travel times for A1. Also, there have been several “incidents” that are not incorporated in the A1/A2 assumptions, such as fish kills due to turbine outages.

We are not proposing a massive sensitivity analysis to all the PATH hypotheses about recent hydropower actions, but rather a caution that prospective model results for A1/A2 are likely over-optimistic (and risk under-estimated) due to this uniform crediting of incremental improvements. It is also important to note that unexpected catastrophies (malfunctions at the projects) are not currently incorporated in model results and are expected to increase with the aging hydropower projects. Also, a less optimistic FLUSH transport model should be included in the analysis.

Natural River Recovery Option (A3)

Option A3 is one of several recovery options being considered which involves restoring free-flowing portions of the migration corridor, and the only one modeled to date in PATH. Option A3 involves natural river drawdown of the four Snake River dams, and BiOp flow augmentation levels. Option B1 (natural river drawdown for four Snake River dams and John Day Dam) has yet to be modeled, but would undoubtedly result in better stock performance than A3 under both life cycle models and under both FLUSH and CRiSP.

We have many historical observations of stock performance with the migration corridor configured in a similar manner to A3, before full development of the hydrosystem. These include estimates of spawners and recruits, SAR, and juvenile survival rates through the mostly free-flowing Snake River. All these historical observations indicated that Snake River spring/summer chinook populations functioned well before the hydropower system was completed (FY96 Conclusions Document). The spawning escapements during this era with 3-5 dams were used to establish recovery standards, and pre-1970 SARs were adopted as performance measures representing healthy populations (Toole et al. 1996; Marmorek and Peters 1998). Similar spring chinook populations above 1-3 dams have not shown the same declines in escapement or survival as Snake River populations since hydropower development (Deriso et al. 1996; Schaller et al. 1996; FY96 Conclusions Document).

For fall chinook, option A3 represents a similar configuration to that currently experienced by the Hanford Reach stock, which is recognized as a healthy stock. The Hanford Reach (Upriver Brights) stock spawns and rears in the only remaining free-flowing section of the Columbia River. Total natural spawners in the Hanford reach averaged around 45,000 in the 60's and 70's, 85,143 in the 80's, and 51,537 in the 90's (through brood year 96). In addition, this natural stock, in combination with some hatchery production (<15%) also supports a large ocean and inriver fishery. For the last ten years, Upriver Bright fall chinook made up an average of 31% of the total ocean catch of Columbia River stocks (55% in 1997). Similarly, Upriver Bright fall chinook made up >50% of the total inriver catch of Columbia Upriver fall chinook in 1997. The Hanford stock provides a concrete historical example of stock performance in a migration corridor configured in a similar manner to A3, a natural, free flowing river.

It is very likely that current hydropower-related stressors would be reduced in the future with a recovery option such as A3. Many hydropower-related stressors now encountered by smolts at the dams (e.g., crowding, stress, injury, and predation at projects) would be eliminated and conditions would be created more in tune with the evolutionary background of the species (e.g., more normal timing of estuary entry). In addition, adult passage survival would be increased.

Outcomes of a natural river recovery option (A3) were much more robust to different hypotheses than were outcomes of transportation-based recovery options (A1/A2) in the WOE report. Unweighted results for A3 for the different jeopardy standards were similar between passage/transport models, differing only for the 24-year survival standard. The fraction of model runs that met the three jeopardy standards for CRiSP/T4 were quite high: 0.76 (24-year survival), 1.0 (100-year survival) and 0.99 (48-yr recovery). The fractions for FLUSH/T1 were: 0.35 (24-year survival), 1.0 (100-year survival) and 1.0 (48-yr recovery). Note that in the December 1997 results circulated to PATH, the FLUSH runs indicated that stocks had a reasonable chance of *recovery* in 24 years, even though the survival standard was difficult to achieve. These seemingly conflicting FLUSH results are explained by high risk of escapements being below threshold levels over a 24-year period (starting in 1996), but with the stocks responding near the end of the period. The recovery standard uses only the last 8 years of the period.

In the WOE report, population performance was better for option A3 than for options A1/A2 for 98% of the models runs (Table 3-1). Most of these exceptions were for the short-term (24-year) survival standard with CRiSP (see discussion above).

Unlike Options A1/A2, which tended toward optimistic assumptions in the analysis, Section 4.3 emphasizes uncertainty for Option A3.

Option A3, under the BKD and Hatchery hypotheses for extra mortality hypotheses, are modeled prospectively with no boost from reduced extra mortality. However, as noted above, these stressors would be reduced with A3. Most of the mechanisms operating under the BKD and hatchery hypotheses are associated with the hydrosystem (eg. stress, disease transmission, and competition during crowded conditions of bypass, collection, and transportation and predation in areas surrounding dams). Crowding within the hydropower system is the only area where evidence exists for an impact of hatchery smolts on wild Snake River smolts in excess of that on lower river smolts. In addition, transmission of BKD has been shown to be greatest in the crowded stressful conditions of collection and transportation. Under A3, crowding in bypass, collection systems, and transportation from the Snake River would be eliminated, and predation at dam outfalls and in dam reservoirs will be reduced. However, none of these reductions in extra mortality are currently modeled under the BKD or Hatchery extra mortality hypotheses for A3.

Predation rate with drawdown (A3)

Changes in predation rates on juvenile salmonids may occur under drawdown of Snake River dams. Anderson (1998) supplies a mathematical argument (Appendix 12) that suggests that predation rates on juvenile salmon may increase if drawdown is implemented. Anderson hypothesized that predation rates will increase under drawdown, in response to increased predator densities. In Anderson's argument, predator densities increase more quickly than the expected decrease in encounter rates between predator and prey as volume decreases faster than water velocity increases. Anderson suggests that decreases in predation will occur in the long term primarily due to compensatory mortality in an environment of lowered carrying capacity. We suggest that an immediate decrease in predation will occur due to factors included in Anderson's mathematical argument but assumed to remain constant.

Anderson's equation states that predation will depend on the encounter rate between predator and prey denoted mainly by α, or the predator search area. The predator search area is the product of the reactive distance of the predator and predator movement. Anderson devotes little discussion to factors that influence α except to state that reactive distance will decrease with turbidity. However, for the sake of his argument, Anderson assumed that turbidity will be minimal under drawdown. Yet Hanrahan et al. (1998; Appendix 13) suggests high export rates of reservoir sediments will continue for 5-10 years, which suggests Anderson's assumption that turbidity will be minimal is unrealistic.

The other influence on α is predator movement. Squawfish, the most common predator in the system, are not adapted to high water velocity habitats (Brown and Moyle 1981). Results from experiments have suggested that increases in water velocity will decrease predation rates as squawfish cannot maintain positions in the water-column where juvenile salmonids are located during migration (Poe et al. 1993, Mesa and Olson 1993, Shivley et al. 1996). Therefore, not only will an increase in water velocity decrease FTT, but it will also decrease the squawfish search area thus decreasing encounter rates with juvenile salmonids.

The affects of high water velocity habitats on predator effectiveness can be evaluated with observations of squawfish consumption rates in free flowing sections. Analysis of squawfish stomachs collected in free flowing sections of streams suggests that juvenile salmonids are an unimportant component of their diet. Buchanan et al. (1981) observed that only 2% of the 1127 squawfish examined in a free-flowing section contained salmonids in their diet. Thompson (1959) found 7.5% of 3546 squawfish contained salmonids in their diet. These and other studies indicate that in free flowing sections squawfish feed mainly on benthic prey such as crayfish (Brown and Moyle 1981, Tabor et al. 1993).

Anderson suggests that predation rates may increase initially under drawdown due to the increase in predator density. However, this response is based only on physical changes to the environment and excludes changes in predator and prey behavior and physiology under the new hydraulic regime. We suggest that predation rates per predator (proximate predator response) will decrease as predator and prey encounter rates will decrease substantially. Evidence for this response is supported by empirical observations of squawfish predation on juvenile salmonids.

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